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**Application No:** GB 0028464.6 **Examiner:** Geoff Holmes
**Claims searched:** All **Date of search:** 20 June 2001

# Patents Act 1977
# Search Report under Section 17

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4J (JK) H1R (RBL RBM RBN)

Int Cl (Ed.7): H04B 1/38 H04M 1/02 H05K 5/00 5/02

Other: Online: WPI, EPODOC, JAPIO

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| A | GB 2329300 A | [NOKIA] | |
| A | GB 2321694 A | [NEC] | |
| X | GB 1434459 A | [MOTOROLA] see figs 1-4 | 1 at least |
| X | US 5574253 A | [GOLOB et al.] see figs 1 and 2 | 1 at least |
| X | US 5068917 A | [SUGIYAMA et al.] see whole document | 1 at least |
| X | US 4443656 A | [LINSE] see figs 1-4 | 1 at least |

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

PATENT SPECIFICATION (11) 1 434 459

1 434 459

(21) Application No. 37806/74 (22) Filed 29 Aug. 1974 (19)
(31) Convention Application No. 401 471 (32) Filed 27 Sept. 1973 in
(33) United States of America (US)
(44) Complete Specification published 5 May 1976
(51) INT. CL.[2] H05K 5/00 7/00
(52) Index at acceptance
H1R 1CX 1P 3A 3C1 3P 3W1
(72) Inventor ALFRED OCKEN

# (54) ENCAPSULATION HOUSING FOR ELECTRONIC CIRCUIT BOARDS OR THE LIKE AND METHOD OF ENCAPSULATION

(71) We, MOTOROLA, INC., a corporation of the State of Delaware, United States of America, of 5725 East River Road, Chicago, Illinois 60631, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates in general to housings for electrical or electronic components and more particularly to an improved method and apparatus for housing and encapsulating such components.

The present invention is set forth and described in the environment of protective housings intended for control devices in vehicles such as, for example, electronic voltage regulators.

With the advent of semi-conductors and the development of companion technologies, such as the thick film art and the like, many new applications are being found for solid state control devices of one sort or another. This includes voltage regulators and other control circuits, for electronic ignition systems for automotive and other motor vehicles.

Because of the relatively hostile environment in which such control devices, e.g. voltage regulators, must operate, some sort of weather or environmental protection is necessary for the desired reliability of operation. The corrosive fluids and other undesirable ambient factors encountered under the hood of an automobile are much too detrimental for such electronic components without some environmental protection. The same is true with respect to high velocity air movements that very likely will be encountered. At the same time, however, there must be an opportunity for adequate heat dissipation for these components or breakdown will occur at some given elevation in ambient temperature.

In the past, protective housings or enclosures employed for these type of control devices, such as a voltage regulator for example, have comprised a simple metallic enclosure, usually open at the bottom, and in which the associated electrical or electronic control board is intended to be placed. Customarily, the interior is then encapsulated with a suitable material for full-range protection. Nevertheless, such encapsulation was more often than not accomplished by hand, one unit at a time. In addition, some means was necessary to position and then maintain the associated circuit board internally of the housing in the required relation before and of course during the encapsulation process.

The result was a unit unduly expensive and time consuming to fabricate, particularly in view of the cadmium or zinc coating required for the metallic housing and the hand operation required for the encapsulation process. Additionally, the finished unit was more often than not oversized when considering the control circuit board that it housed. This translates into even greater expense when considering the cost of the extra encapsulation material required. In many cases, the heat dissipation capacity has been deficient in that the encapsulation material effectively isolated the internal components from the outside ambient.

Accordingly, it is one object of the present invention to provide a protective housing for electrical components operative in

A more particular object of the present a hostile environment which does not exhibit the foregoing deficiencies.

invention is to provide a protective housing for an electronic voltage regulator or the like for underhood operation in a motor vehicle which is less costly to produce, more compact in size, and ensures more reliable operation.

Another object of the present invention is to provide an improved method of final assembly and encapsulation for such voltage regulator unit or other control device which is adapted to automation, or at least multi-

SPECIFICATION AMENDED - SEE ATTACHED SLP

unit production as contrasted to hand operation.

Yet another object of the present invention is to provide a protective housing for a voltage regulator or other device which is non-metallic, yet stabilized in configuration notwithstanding being subjected to relatively high ambient temperatures in operation and further which is non-reactive to other ambient factors.

Still another object of the present invention is to provide a protective housing of the foregoing type wherein internally positioned guide rails ensure the associated circuit board is optimally positioned within the housing for proper heat dissipation action.

It is another object of the present invention to provide a protective housing of the foregoing type which contemplates vertical assembly of the associated control circuit boards and permits proper positioning therein by the action of gravity.

A further object of the present invention is to provide a protective housing of the foregoing type suitable for stacking in a vertical, side-by-side relation wherein one portion of each such housing effectively overlaps a portion of an adjacent housing so as to permit a continuous encapsulation process therefor.

According to the present invention there is provided a protective enclosure for encapsulating an electrical control circuit arranged on a circuit board, comprising a housing structure formed with a base, vertically upstanding side walls and front and back end walls, open at the top, with a pair of guide rails, each rail extending vertically on the interior of a respective one of said side walls, said guide rails defining a pair of congruent channels in said side walls extending contiguous to one of the end walls for guiding the insertion of the control circuit board to a position flatly against the one end wall upon inserting the control board into the housing, said housing further including a ledge extending laterally and outwardly from the top of one end wall, said ledge having a bottom edge, said other end wall having a top edge, the height of the bottom edge of said ledge above said base in relation to the height of the top edge of the other end wall above said base being dimensioned such that said housing is adaptable for stacking in multiple units in a vertical, side-by-side relation whereby said laterally extending ledge of one housing overlies the top edge of the next adjacent housing.

In one embodiment of the invention, a protective housing is provided for accommodating a circuit board with components comprising a voltage regulator or other like control device. The housing is designed to accept the insertion of the circuit board from a vertical direction with tracks or guide rails on opposing side walls which serve to guide or steer the circuit board to its intended position within the housing by the action of gravity.

The housing itself is formed of a non-metallic, thermosetting plastic material which remains stabilised in its set condition despite elevated temperatures to which it may be subsequently subjected. The finished, i.e., encapsulated, unit is designed for mounting on the fire wall or interior wall of a vehicle engine compartment with the associated heat sink interior of the housing positioned adjacent thereto for appropriate head dissipation action. Alternatively, the housing may be mounted directly on the motor vehicle's alternator unit.

For facilitating the required encapsulation process, the housing includes a laterally projecting lip for overhanging an edge of an adjacent housing when both are stacked together in a vertical side-by-side relation. The housing units are maintained in this relation by tubular rods or other fastening means passing through apertures extending therethrough and which subsequently serve as the holes necessary for mounting the individual finished units.

The present invention will now be described by way of example only with particular reference to the accompanying drawings, wherein:

Figure 1 is a front elevational view of a protective housing of the present invention;

Figure 2 is a cross-sectional view of the housing of Figure 1 taken generally along lines 2—2;

Figure 3 is a perspective view of an associated circuit board forming an electronic voltage regulator and which is intended to be encapsulated in the housing of Figure 1;

Figure 4 is a perspective view of the finished and encapsulated voltage regulator unit and

Figure 5 is a perspective view of a plurality of such housing units of Figure 1 shown in a vertically stacked, side-by-side relation for encapsulation in a multiple-unit assembly.

Referring now to the drawing, the finished voltage regulator unit is shown in Figure 4, and includes a protective housing 12. The housing 12, in one embodiment of the present invention, is shown in vertical plan view in Figure 1. As seen in Figures 2, 4 and 5, the housing 12 is in the form of an upright, narrow-based enclosure defined by upstanding walls 12*a*, 12*b*, 12*c* and 12*d* in conjunction with the bottom wall or base 12*e*. Support members 13*a*, 13*b* are formed on the bottom of the housing front and back walls 12*a* and 12*b* have a substantially wider dimension than the respective side walls

12*c* and 12*d*, say, for example, by a ratio of some 4:1. However, it is to be understood that this is in no way critical to the present invention, and the dimensions of the housing 12 will be, and indeed are expected to be, tailored to best accommodate the interior-placed circuit board arrangement to be discussed subsequently.

In any event, housing 12 further includes a pair of apertures 14 and 16 intended for mounting the overall control device, in this case the voltage regulator under the hood, or elsewhere, in its intended application environment. Apertures 14 and 16 serve a further purpose which likewise will be covered in more detail hereinbelow. However, it may be noted that apertures 14 and 16 extend entirely through housing 12 on respective sides immediately above the base portion 12*e*. As best seen in Figure 2, apertures 14 and 16 are closed off from the interior of housing 12. In addition, while aperture 14 is essentially circular in cross-sectional area, aperture 16 is somewhat elongate, as will be appreciated upon reference to Figure 1. With this particular hole configuration, the control unit, when fully assembled, may be mounted directly on the alternator assembly (not shown) of the associated vehicle or, alternatively, on an appropriate location on the fire wall or interior wall of the engine compartment.

Housing 12 is constructed to accommodate an associated circuit board, such as that identified at 20, comprising a control device of some sort or another, such as an electronic voltage regulator. Circuit board 20 includes substrate element 22 and heat sink 24. Heat sink 24 is formed as a flat board having a front and rear major surface area. The regulator preferably is designed using a thick film technique. This permits substrate element or base 22 to be utilised on which certain of the circuit paths, as well as the necessary resistance elements, may be formed directly therein. The associated discrete transistor devices and capacitor elements may then be mounted physically thereon and suitably interconnected, such as by solder reflow techniques or the like. The entire substrate assembly may then be cemented, taped or otherwise attached to the front major surface of a metallic heat sink 24 of a suitable material, such as aluminium, for optimum heat dissipation capabilities. Additional circuit components may be separately attached or cemented to heat sink 24 as well, for example, the power switching transistor 26. The necessary external control leads 28 are then attached directly to the substrate element 22 at appropriate terminal points.

As will be appreciated from Figure 2, a track or guide rail 18 extends downwardly along the interior of each of the side walls 12*c* and 12*d*. Guide rails 18 are shaped to define a flared or tapered opening, wider at the top than at the bottom, such that the circuit board assembly 20 may be easily inserted from a vertical direction into housing 12 and permitted upon release to be guided to its proper position by the pull of gravity. The intended position contemplates the heat sink 24 lying immediately adjacent to and in substantial contact with the upstanding wall 12*b*, as best seen in Figure 5. In this referenced position, maximum heat transfer will be permitted between the heat sink 24 and the wall 12*b* of housing 12 and thus out to the ambient. It also prevents the isolation of the heat sink and circuit component parts by the subsequently added encapsulation material which may otherwise get between the heat sink and wall 12*b*.

With the circuit board assembly 20 properly seated and positioned within the housing 12, encapsulating material 30 may then be poured into and thereby fill the remainder of the interior space. The material 30 is then allowed to set or harden. The finished or assembled unit is shown in Figure 4. The result is an hermetically sealed voltage regulator unit with only the control leads 28 protruding therefrom, as indicated, for subsequent interconnection at appropriate terminal or reference points within the alternator and ignition systems (not shown).

The housing may be fabricated from any suitable material. In its preferred forms, however, it is compression moulded from a non-metallic, but permanently stabilised plastic compound. By permanently stabilised, it is meant that once formed by the thermosetting material, it remains substantially in that form notwithstanding that the housing may be subjected to elevated ambient temperatures during subsequent operation.

A significant design feature of the housing 12 is its adaptability to multi-unit assembly, including the desired encapsulation process therefor. As indicated in Figure 5, a plurality of housings 12 may be arranged in an upright, side-by-side relation. A lip or ledge 12*f* extends laterally and outwardly from the top of wall 12*a* and overhangs a top edge portion 12*g* of wall 12*b* of the next adjacent housing 12. A shallow channel or trough 12*h* is located centrally in the top of ledge 12*f*, as shown.

As seen in Figure 2 the underside or bottom edge 12*k* of the lip 12*f* lies in a horizontal plane which includes the top edge 12*g* of the rear wall 12*b*. Thus, when the housings are ganged or stacked in vertical side-by-side relation as shown in Figure 5, the bottom edge 12*k* of the lip 12*f* overlies the top edge 12*g* of the rear wall 12*b*. The

portion of the side wall 12*i* which extends to the top edge 12*j* of the ledge is a smooth extension of the channel 12*c* to assist in inserting the board 20 into the guide rails and starting to move it rearwardly toward the rear wall 12*b* of the housing.

The plurality of housings 12 are maintained in the aforedescribed side-by-side, vertically-stacked, position by a pair of rod-like members or shafts 36, extending through apertures 14 and 16. In this referenced position, the circuit board assemblies 20 may be inserted into an associated housing 12 from essentially the vertical direction. As previously described, the action of gravity in conjunction with the referenced internal guide rails 18 at respective sides thereof is then effective to correctly position and maintain the circuit board assembly 20 within the housing 12.

With the completion of the insertion of circuit board assemblies 20, the interior of housings 12 may be suitably encapsulated. In the preferred form, the encapsulation will be accomplished by an automated process. However, even where a hand operation is utilised, the encapsulation itself may be effected on a multi-unit basis.

In operation, the encapsulating material may be dispensed into the vertically stacked housings from a stationary vessel (not shown) as the housings 12 themselves are transported or moved along a predetermined path as a group or assemblage. Troughs 12*h* are effective to maintain the liquid encapsulation material 30 within a prescribed area as defined by such troughs. The overlapping of the housings, i.e., ledge 12*f* positioned on top portion 12*g* of the next adjacent housing, serves to prevent the encapsulating material from spilling between housings. As a consequence, the pouring of the encapsulating material may be effected on a continuous basis, rather than a start and stop action for each individual housing. This is a particularly attractive feature, and especially with regard to adapting to a suitable automation process.

Alternatively, it may be preferred to first partially fill the interior of housing 12 with sand or like material, and then fill the remaining space with the usual encapsulation material. The latter permeates the sand or filled material before hardening to its final state. This procedure is attractive because the sand is far less in cost than any encapsulation material which can be used. Further, the sand enhances the heat dissipation capabilities of the assembly as a whole.

While certain specific embodiments have been disclosed and described herein, it is of course to be understood that other and further modifications and alternative constructions or procedures may be effected. For example, it may be preferred to maintain the assemblage of housings 12 and depicted in Figure 5 in a stationary position while moving the vessel from which the encapsulation material is poured along a predetermined path. This of course would be the method employed when utilising a hand operation.

WHAT WE CLAIM IS:—

1. A protective enclosure for encapsulating an electrical control circuit arranged on a circuit board, comprising a housing structure formed with a base, vertically upstanding side walls and front and back end walls, open at the top, with a pair of guide rails, each rail extending vertically on the interior of a respective one of said side walls, said guide rails defining a pair of congruent channels in said side walls extending contiguous to one of the end walls for guiding the insertion of the control circuit board to a position flatly against the one end wall upon inserting the control board into the housing, said housing further including a ledge extending laterally and outwardly from the top of one end wall, said ledge having a bottom edge, said other end wall having a top edge, the height of the bottom edge of said ledge above said base in relation to the height of the top edge of the other end wall above said base being dimensioned such that said housing is adaptable for stacking in multiple units in a vertical, side-by-side relation whereby said laterally extending ledge of one housing overlies the top edge of the next adjacent housing.

2. A protective enclosure as claimed in claim 1 wherein the width of each of said channels measured in a plane parallel to the side walls progressively tapers from a point at the top of the side walls to a point toward the bottom of the side walls whereby the associated control circuit board may be inserted from a vertical direction and positioned as aforesaid within said housing by the action of gravity.

3. A protective enclosure as claimed in claims 1 and 2 wherein the width of each channel tapers progressively along the entire length of the channel.

4. A protective enclosure as claimed in claims 1 to 3 wherein the one wall is the front end wall, the other wall is the back end wall and the channels are contiguous to the back end wall.

5. A protective enclosure as claimed in claim 1 wherein said edges each lie in a plane substantially perpendicular to the vertical axis of the housing.

6. A protective enclosure as claimed in claims 1 to 5 wherein the ledge extends the full width of the front end wall, the ledge having a top edge surface, each side wall having a portion extending to the top edge

surface of the ledge, the portion being formed as a smooth extension of the channel.

7. A protective enclosure as claimed in claims 1 to 6 wherein said housing is formed of a non-metallic, thermosetting but permanently stabilised material when set notwithstanding being subjected to elevated ambient operating temperatures, which housing is compatible with known encapsulating techniques.

8. A protective enclosure as claimed in claims 1 to 7 wherein said housing further includes a shallow trough positioned centrally of said laterally extending ledge for confining a stream of encapsulating material when poured into the interior of said housing to essentially the area of said trough.

9. A protective enclosure as claimed in claims 1 to 8 wherein said housing includes a pair of apertures extending through said front and back walls but sealed off from the interior of said housing, said apertures being of a size and configuration to permit mounting of said housing at a plurality of locations as well as being adaptable for providing a means of support for stacking of said housings together in multiple units during assembly and encapsulation of the associated control circuit board.

10. A method of encapsulating control devices assembled on a heat sink circuit board comprising the steps of forming a housing having a base, upstanding front and rear end walls and side walls, open at its top, with a pair of guide rails each rail extending vertically downwardly on the interior of a respective one of the side walls; inserting the circuit board into the housing; positioning the circuit board within the housing flatly against one of the end walls by guiding the side edges of the circuit board on the guide rails; and pouring the encapsulating material into the housing in an amount sufficient to cover the control device assembled on the circuit board.

11. A method of encapsulating control devices assembled on a heat sink circuit board as claimed in claim 6 wherein the forming step includes forming a plurality of the housings, each housing having a lip extending laterally and outwardly from a top portion of one of the end walls, further comprising vertically stacking a plurality of the housings in a side-by-side relation whereby the lip of one housing overlaps a top portion of the next adjacent housing, inserting and positioning a circuit board into each housing as aforesaid, and continuously pouring encapsulating material into each housing consecutively in an amount sufficient to cover the circuit board in each housing.

12. A method of encapsulating control devices assembled on a heat sink circuit board as claimed in claims 10 or 11 wherein the lip extends from one end wall and the positioning step includes positioning the circuit board against the other end wall.

13. A method of encapsulating control devices as claimed in claims 10 to 12 wherein the forming step includes providing each said lip with a shallow trough in a substantially central location thereof, and further comprising the step of constraining the encapsulation material within essentially the area defined by said troughs during the pouring of the encapsulation material into said housings.

14. A method of encapsulating control devices as claimed in claims 10 to 13 wherein the forming step includes providing mounting holes in the bodies of said housings and the step of vertically stacking the plurality of housings in a side-by-side relation includes inserting rod-like members through said mounting holes to support said housings as a group.

15. A method of encapsulating control devices as claimed in claims 10 to 14 wherein the step of forming said plurality of housings includes the fabrication of the same by compression moulding from a non-metallic, thermosetting, but permanently stabilised plastic material.

16. A method of encapsulating control devices as claimed in claims 10 to 15 wherein the pouring step includes first continuously pouring sand into said individual housings consecutively, said sand filling at least half of the internal volume of the respective housings, and then continuously pouring encapsulating material into each of said housings consecutively to fill the remaining volume thereof and further comprising curing the encapsulating material.

17. A protective enclosure substantially as hereinbefore described and as shown in the accompanying drawing.

For the Applicants:
F. J. CLEVELAND & COMPANY,
Chartered Patent Agents,
Lincoln's Inn Chambers,
40—43 Chancery Lane,
London WC2A 1JQ.

Printed for Her Majesty's Stationery Office by Burgess & Son )Abingdon), Ltd.—1976.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1434459 COMPLETE SPECIFICATION
1 SHEET
*This drawing is a reproduction of the Original on a reduced scale*

FIG 1

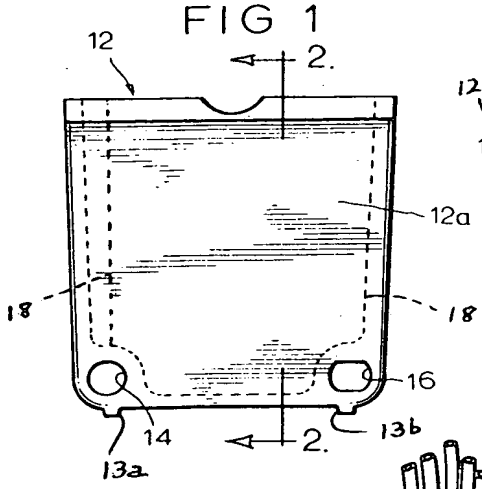



FIG. 2

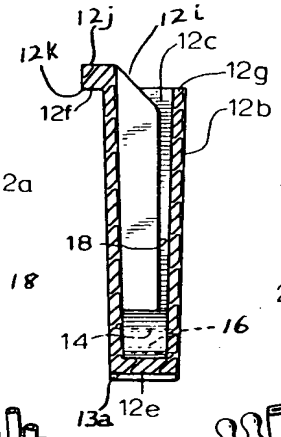
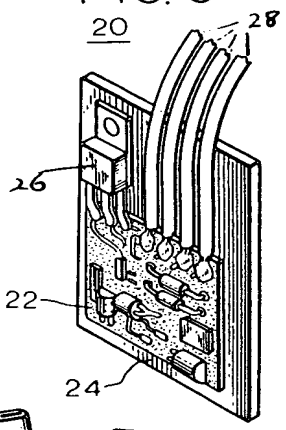



FIG. 3



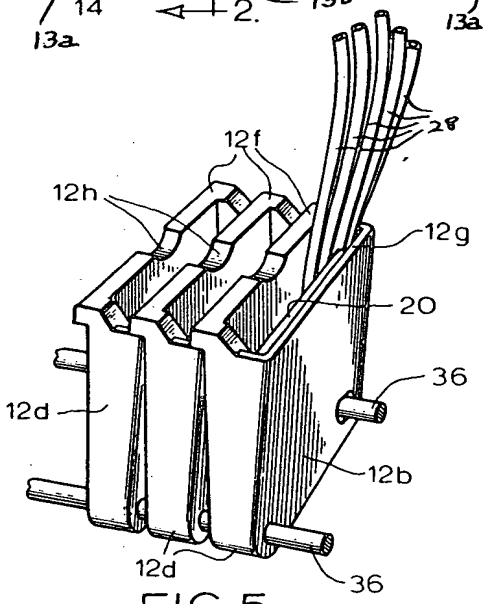




FIG. 5

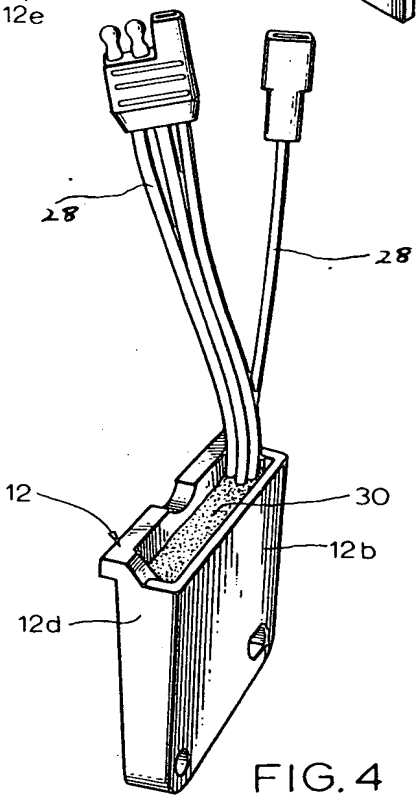



FIG. 4

PATENTS ACT 1949

SPECIFICATION NO 1434459

The following amendments were allowed under Section 29 on 28 March 1977:-

Page 2, line 34, *after* board *insert* which includes or is mounted on a heat sink

Page 4, lines 77 and 78, *delete* arranged on a circuit board, *insert* arranged on a circuit board which includes or is mounted on a heat sink

Page 5, lines 31, 47, 64, 70, 80, 89 and 96, *after* encapsulating *insert* a

Page 5, lines 32, 48 and 65, *delete* devices assembled on a heat sink *insert* device assembled on a

Page 5, line 33, *after* board *insert* which includes or is mounted on a heat sink

Page 5, line 49, *for* 6 *read* 10

Page 5, lines 71, 81, 90 and 97, *for* devices *read* device

Page 5, line 95, *for* plastic *read* plastics

THE PATENT OFFICE
*20 May 1977*

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